Crockery Creek Speaks

Community Survey Report, 2022

Grand Valley State University
Social Science Lab

Ottawa Conservation District

Acknowledgments

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Ravenna High School Stream Team Sponsors:

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Executive Summary

The Crockery Creek Speaks community survey was conducted by the Grand Valley State University (GVSU) Social Science Lab as part of the Ottawa Conservation District's Crockery Creek and Sand Creek restoration project. The community survey gathered input from rural residents and farmers living in the Crockery Creek watershed about their thoughts on the status and management of water quality in the area.

The Ottawa Conservation District assists landowners in Ottawa County, Michigan with securing funding and implementing projects that protect and improve land and water resources. The Conservation District is a non-regulatory, local unit of state government that coordinates voluntary conservation projects on private land and connects landowners to programs that can support and enhance their conservation goals.

The Social Science Lab is an applied research center at GVSU that helps people solve problems. The lab assists community organizations entrusted to steward public dollars with making targeted, strategic investments that consider community members' values, opinions, concerns, and behaviors. We aim to incorporate the wealth of local knowledge held by residents into the plans and priorities that drive our partners' work.

The Crockery Creek Speaks survey was mailed to 2,552 owners of rural residential and agricultural properties in the Crockery Creek watershed. We received completed questionnaires from 323 of these landowners, who had a lot to say about the history of the creek and its importance to the community. Survey respondents were older on average than the typical watershed resident, with the result that our survey captured many stories about how residents have seen the creek change over time.

We learned that residents in the Crockery Creek watershed are devoted outdoor enthusiasts who care deeply about the health of their creek and the quality of the riparian habitat supporting fish and wildlife. Many have invested their personal money and time in amending their properties to control erosion and improve water quality. Long-term residents have witnessed changes in the vitality of the fishery in Crockery Creek and some were concerned about the growth in the scale of agricultural operations in the watershed. However, we also observed that farm operations were more likely to use water quality best management practices as their operations scaled-up and thus had more capital to invest in conservation. We heard that residents were underwhelmed with historic management actions taken by state authorities and are impatient for someone to get-going on fixing the problems they see in Crockery Creek.

In the report that follows, we review background information on the watershed and the community survey before diving into what respondents told us about living near the creek, their conservation priorities and concerns, as well as reported use of water quality best management practices on properties in the watershed. The report concludes with recommendations for the Conservation District's community engagement plan, highlighting future focal points for public communication and opportunities to maximize conservation investments.

Background and Methods

Crockery Creek is the largest tributary of the Lower Grand River watershed, serving as the drainage basin for 102,318 acres of predominantly agricultural land in Muskegon, Ottawa, Newaygo, and Kent Counties (LGROW, 2010). The watershed houses diversified farmsteads that range in scale from backyard gardens to commercial operations and include commodity production, fruit growers, hay/silage production, canning crops, livestock, dairy, and poultry production. Many property owners also maintain forested land for hunting and recreation.

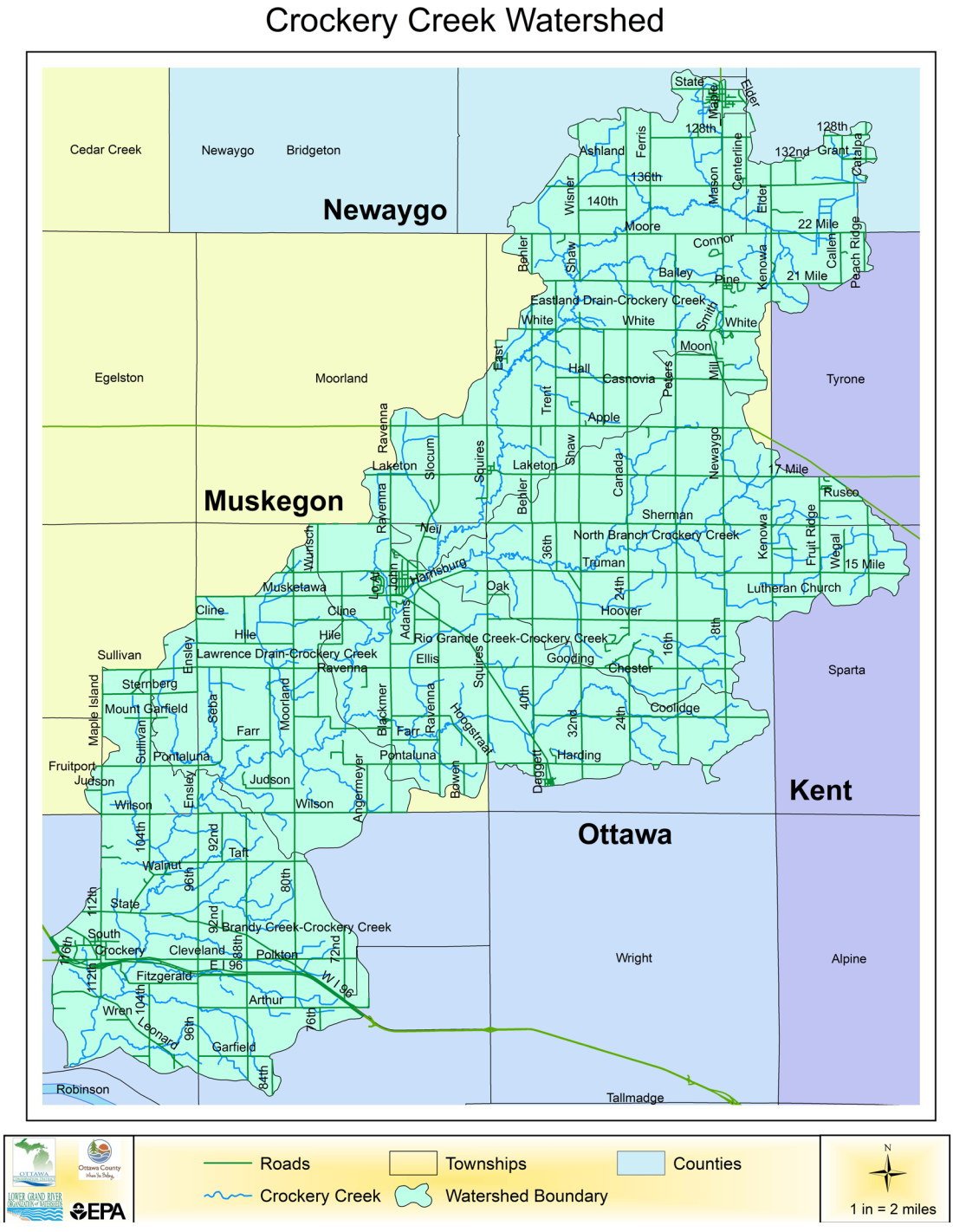

Figure 1. Crockery Creek watershed map

Crockery Creek is designated as a waterway with unstable hydrology, meaning that land development and wetland loss throughout the creek's drainage basin has intensified the flow volume received by the creek during rain events (Fongers, N.d.). An increased flow volume moves water at higher speeds, carrying more pollutants into Crockery Creek as well as making streambanks more vulnerable to erosion. Additionally, Crockery Creek has a total maximum daily load (TMDL) target for *E. coli* bacteria dating back to 2003, which indicates that routine statewide *E. coli* monitoring identified elevated levels of fecal contamination in the creek (LGROW, 2010). The *E. coli* TMDL for Crockery Creek remains in effect after 2019 monitoring results found *E. coli* levels exceeding the recreational water quality partial body contact limits (MI EGLE, 2019). Fecal contamination is a persistent problem in the watershed.

Rural communities are at a public infrastructure disadvantage. Low population densities generate an insufficient tax base to support basic forms of public infrastructure commonly observed in urban environments, including water, sanitation, home heating, transportation, and internet services (Shaft and Brown, 2011). It is believed that aging and malfunctioning septic systems are common in rural communities across Michigan and that these systems contribute *E. coli* pollution to ground and surface waters (Flowers et al., 2019; Palmer et al., 2019). There are approximately 1.3 million onsite septic systems in Michigan, and Michigan counties with point-of-sale inspection requirements have found failures in 18-27% of inspected systems (Blakely, 2021). The cost of installing a new septic system is substantial. Replacements completed with the help of the Ottawa Conservation District in 2022 as part of the Crockery Creek and Sand Creek restoration project were billed as high as $20,000 (personal correspondence). It is easy to understand how septic systems can become "out of sight, out of mind" – until something is seriously wrong.

Another characteristic of rural communities worth considering is the trend of cropland and livestock consolidation observed in the agricultural sector. From 1987-2012, the number of large crop farms (>1,999 acres of cropland) in the U.S. nearly doubled while the number of midsize farms (100-1,999 acres of cropland) nearly halved (MacDonald et al., 2018). There was some growth in small farms (<100 acres of cropland), but not enough to offset the loss of midsize operations. Likewise, the midpoint for broiler flocks in the U.S. increased from 300,000 head in 1987 to 680,000 head in 2012 (127% increase), the midpoint for dairy cow herds increased from 80 head in 1987 to 900 head in 2012 (1,025% increase), and the midpoint for hog sales increased from 1,200 head in 1987 to 40,000 head in 2012 (3,233% increase) (MacDonald et al., 2018). Technological innovations and improved management in confined feeding operations have driven these trends, with large farms better positioned to make investments in labor-saving technologies that facilitate their ability to capitalize on economies of scale. While 90% of U.S. farms remain family owned and operated (MacDonald et al., 2018), the size, scale, and scientific management of farms in the U.S. and Michigan have grown rapidly in recent decades, as have public concerns about the nutritional quality and environmental impact of our food supply.

It is against this landscape that we sought input from Crockery Creek rural residents and farmers about their experiences with and management of local water resources. They had a lot to say! Their stories were so insightful and observations so descriptive, we allow them to speak for themselves in the report that follows. Thanks to everyone who took the time to speak for the creek.

Survey Methods

The Crockery Creek Speaks questionnaire included items from the social indicators planning and evaluation system (SIPES), which was created by Great Lakes Land Grant universities to standardize social science data collection about water quality throughout the basin and is currently maintained by Michigan State University (Genskow and Prokopy, 2011). Additional items of interest to the research team were included to assess perceptions of accessibility at parks, opinions about wetland conservation, and viewpoints on drain projects.

In total, 2,552 households were mailed requests to complete the Crockery Creek Speaks survey from June-July 2022. Prior to mailing the survey, the GVSU Social Science Lab and the Ottawa Conservation District attended one monthly meeting per township in the watershed to explain the purpose of the study and distribute promotional materials. Following a modified tailored design protocol (Dillman et al., 2014), three contact attempts were made with each household. The first contact consisted of a pre-notice letter, followed one week later by a questionnaire packet and postage paid return envelope. A final thank you/reminder post card was mailed to each household two weeks later.

The sampling frame for the Crockery Creek Speaks survey was drawn from tax parcel records maintained by the county GIS offices. Records for all tax parcels within the five subbasins comprising the Crockery Creek watershed were obtained from Muskegon, Ottawa, Kent, and Newaygo Counties. The original lists included approximately 6,000 parcels. The parcel identification number for each record was used to verify the property owner and mailing address against the online property search tools maintained by each county, where the township zoning code and aerial imagery for each parcel could be examined.

We developed the following inclusion criteria: 1) there was a 100% principal residence tax exemption on the parcel, indicating that the property owner was likely a permanent resident; 2) the property was zoned as an agricultural, rural residential, or residential-agricultural parcel within its corresponding township, indicating that the parcel was not connected to municipal water/sewer; 3) the parcel and mailing addresses were identical, indicating that the property was currently occupied or the landowner was a permanent resident in the watershed; and 4) the property owner information on the digital property search tool matched the property owner information on the records obtained from the county, indicating that the information listed was valid. Following these criteria, we conducted a census of all 2,552 farming families and rural property owners who we identified as permanent residents within the watershed.

Exceptions to the principal residence tax exemption inclusion criterion were observed in cases of vacant land ownership. Absentee landowners, such as land companies with mailing addresses outside the watershed boundaries, were excluded from the sampling frame. However, owners of vacant land with mailing addresses inside the watershed were included. These included owners of land that is wooded or farmed with no structures who live in one of the villages within the watershed. Additionally, to avoid confusion among neighbors, rural residential properties immediately adjacent to incorporated villages were excluded. A handful of residents who own properties adjacent to the principal investigator's home in the watershed were excluded from the survey sample and instead invited to participate in an informal pilot test. The research team is grateful for their invaluable feedback.

Survey Participants

We received 323 completed questionnaires, an adequate number to achieve a 5% margin of error at a 95% confidence level. That is, we can expect that our survey estimates are within +/- 5% of the actual population value on a given item with 95% certainty. While we received the targeted number of responses, it is worth noting that the response rate was considerably lower than ideal, at approximately 13%.

We compared the demographic characteristics reported by survey respondents to U.S. Census Bureau American Community Survey (ACS) population estimates for the watershed to see how well our survey respondents matched the actual description of an average resident in the watershed. This helps us identify how accurately our survey data can be generalized to represent the average views of a watershed resident and highlights viewpoints that may have been left out. Because watersheds do not conform to political jurisdictions (i.e., counties, townships, or cities), accessing ACS estimates for watersheds is limited to a few public datasets, among which is the U.S. EPA EJScreen.

The average Crockery Creek Speaks respondent was a college-educated, Caucasian male of a mature age (Table 1). Compared to ACS estimates of the actual population characteristics of the watershed, male respondents were slightly overrepresented in our data compared to female respondents. College educated survey respondents were also overrepresented in our data. Forty-four percent of survey respondents reported having a four-year college degree or graduate degree, whereas the ACS estimates that 22% of watershed residents have attained this level of education. Residents aged sixty-five years and older are also overrepresented at 46% of the survey population compared to the ACS estimate that 14% of the watershed population falls into this age range. The racial representation of survey respondents accurately reflected the racial characteristics of the watershed population, which is predominantly white. On average, respondents reported having lived in their current residence for 27 years, although the range of years lived in Crockery Creek watershed was large, from less than one year to 82 years.

When interpreting our survey responses, it's important to consider that there will be some degree of error related to the fact that survey respondents are more highly educated and have a wealth of life experiences compared to the average watershed resident. Rather than asserting that survey responses capture an exact representation of the percentage of watershed residents who are knowledgeable about water quality issues or using best management practices, we recommend reading this report for broad patterns across responses that point to successes and opportunities in conservation action.

While the demographic characteristics of individuals are one indicator of differences in life experience and perspective, the type of property respondents manage is another important indicator of differing ways that landowners interact with land and water resources in Crockery Creek watershed. We therefore used responses to questions about the number of acres respondents manage, and livestock and cropping management practices to classify respondents into three categories.

Table 1. Demographic characteristics of respondents

Variable	N	% / Mean (SD)	ACS Estimates
Gender			
Male	184	58%	50%
Female	119	38%	50%
Race/Ethnicity			
White/Caucasian	297	96%	94%
People of color	14	4%	10%
Age	302	61 (14)	--
18-64 years old	164	54%	75%
65 years and older	138	46%	14%
Education Level			
High school/ GED or less	65	20%	46%
Some college	78	25%	20%
Two-year college degree	37	12%	11%
Four-year college degree	138	44%	22%
Residency	317	27 (17)	--
10 years or less	70	22%	--
11-20 years	59	19%	--
21-30 years	73	23%	--
31-40 years	44	14%	--
41-50 years	48	15%	--
More than 50 years	23	7%	--

Fifty-three percent of respondents (n=165) were rural residential landowners with houses on less than 80 acres (Figure 2). Thirty-two percent of respondents (n=99) owned small farms with farm animals or cropping systems on less than 80 acres. Fifteen percent of respondents (n=47) operated large farms with farm animals or cropping systems on 80 or more acres of land. A few respondents (n=12) could not be classified due to missing information. Throughout the report, we note similarities and differences in responses across the type of property respondents own as we expect that the way residents use their properties plays an important role in conservation techniques.

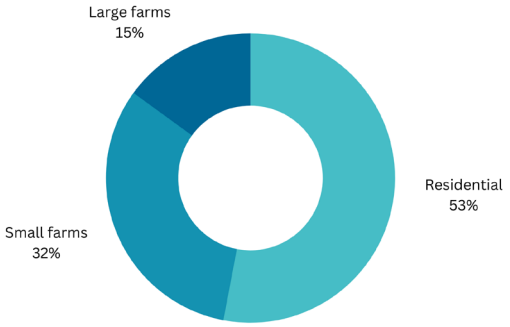

Figure 2. Survey respondents by landowner type

Living in Crockery Creek Watershed

The difficulty with managing water is that, of course, it flows. What happens on one person's property can potentially have far-reaching impacts as water travels from land to tributary, eventually making it all the way to the Great Lakes. It follows that water management is both highly consequential and often controversial, with communities becoming mired in conflict over who is to blame for water problems (Armstrong et al., 2019). We wanted to learn about what Crockery Creek residents see as the good, the bad, and the ugly in terms of local water recreation and water quality. We therefore asked questions about how people enjoy the creek, how satisfied they are with county drain maintenance, and how much confidence they have with water management actions taken by various actors in the watershed.

Enjoying Crockery Creek

To learn about how residents interact with and enjoy Crockery Creek, we asked survey respondents how frequently they visit parks with water access in the watershed and which water-based recreational activities are most important to them. Within the watershed, Patterson, Thatcher, Moore, Grose, and Blanch Lake City Parks all have water access, as does the Musketawa Trail. As reported in Table 2, most respondents reported visiting at least one of these parks 1-5 times per month during the summer, although approximately one-third had never visited any of the parks.

Table 2. Monthly park visitation

Frequency	%
0 visits	36%
1-5 visits	53%
6-10 visits	6%
More than 10 visits	5%

Fishing and hunting were most frequently ranked as respondents' favorite water recreation activities, followed closely by enjoying scenic beauty (Figure 3). Survey respondents offered their recollections of time spent at the creek in comments on the back cover of the

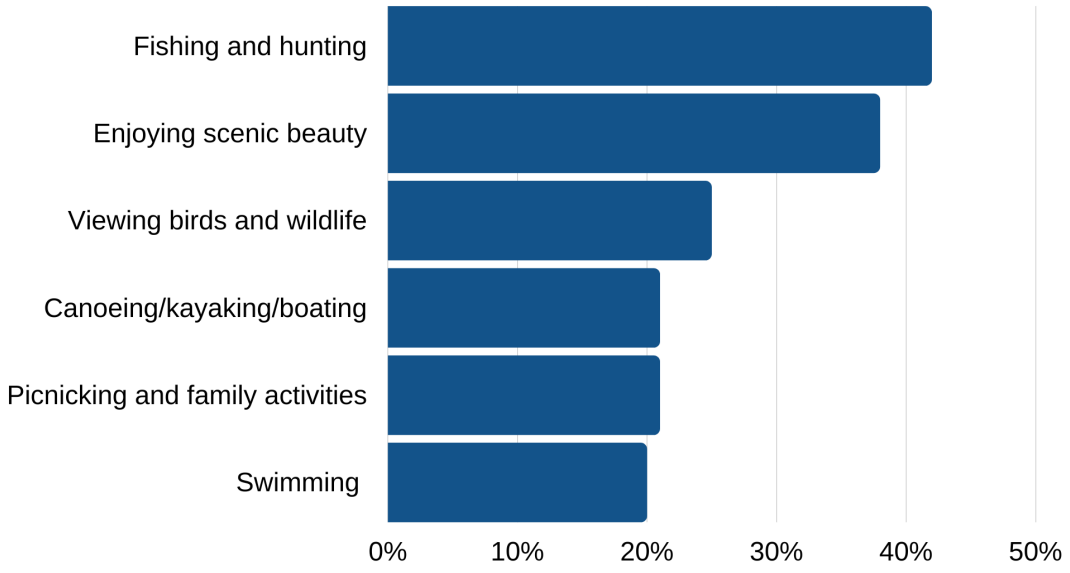

Figure 3. Percent of respondents ranking each activity the "most important"

questionnaire booklet, describing pastimes with abundant fishing. One respondent wrote, "I went swimming as a kid in our swimming hole. I speared suckers in the spring, fished for small mouth bass in the summer. In later years I fished steelhead trout, brown trout, and salmon." Likewise, another recalled, "Growing up, we used to have much larger and longer spring runs of suckers and steelhead. Summertime we used to fish rock bass and carp." Still another remembered, "During the summer months in the later 1940's and early 1950's I swam and played in the creek almost every day. The water was pure and drinkable." These memories evidenced a great fondness for the creek but often dovetailed with present-day concerns.

A student researcher in the Social Science Lab who is pursuing a degree in occupational therapy wanted to learn about park features that promote greater access to enjoyment of Crockery Creek. We therefore asked respondents to evaluate how safely they or a companion would be able to reach the waterway access at each park in the watershed if they had a physical disability that limited walking (Figure 4). Many respondents said that the Musketawa Trail (n=98), Grose Park (n=78), and Thatcher Park (n=65) have very safe water access options.

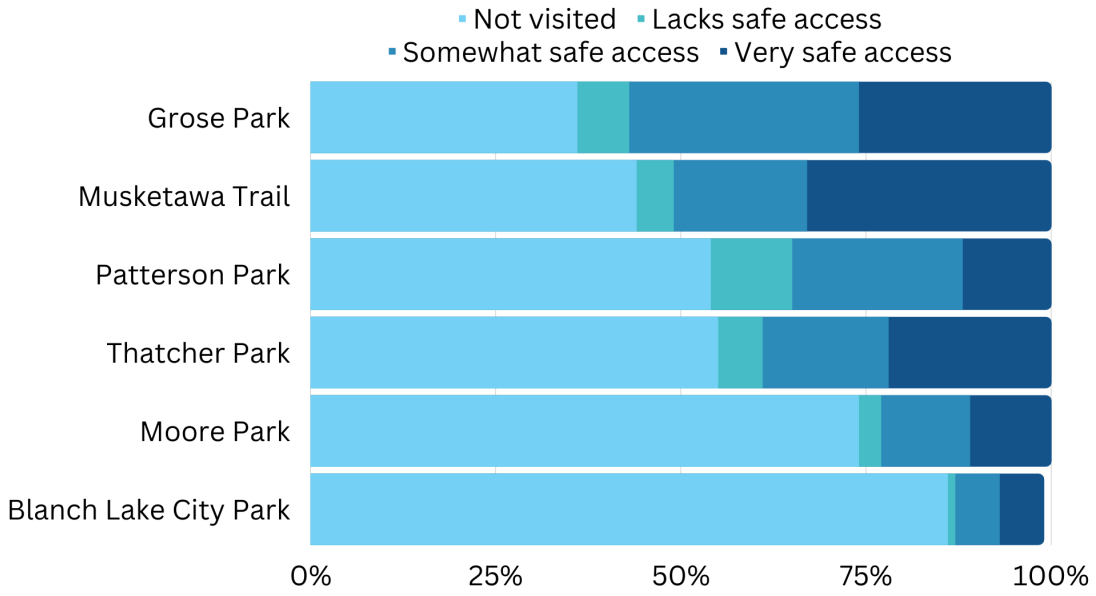

Figure 4. Evaluations of park accessibility

When asked why they would recommend a particular park to someone with a mobility impairment, paved walking trails, flat parking lots, and wheelchair ramps leading to spots with scenic views were frequently mentioned as important features making parks more accessible. Spending time at the creek remains important to residents in the present as it was in the past. As one respondent commented, "We love the natural beauty of our Michigan and especially local water areas! We especially like canoeing, kayaking, fishing, and exploring." Another wrote, "I certainly do appreciate clean water, picnicking, viewing wildlife and birds, enjoying scenic beauty." Accessibility ensures that all residents and their families can enjoy the creek and experience the health benefits associated with outdoor activities.

County Drain Maintenance

While conducting public outreach prior to distributing the survey, the research team learned that many residents from Muskegon County had received large assessments on their property tax bills for drain projects completed by the county Water Resources Commission.

We therefore asked all respondents their opinions about whether the total cost and scope of drain projects and the amount individual landowners were assessed were too much, the right amount, or not enough money. We also asked whether routine drain maintenance and repair, and opportunities for public input on drain plans were given too much, the right amount, or not enough attention (Figure 5).

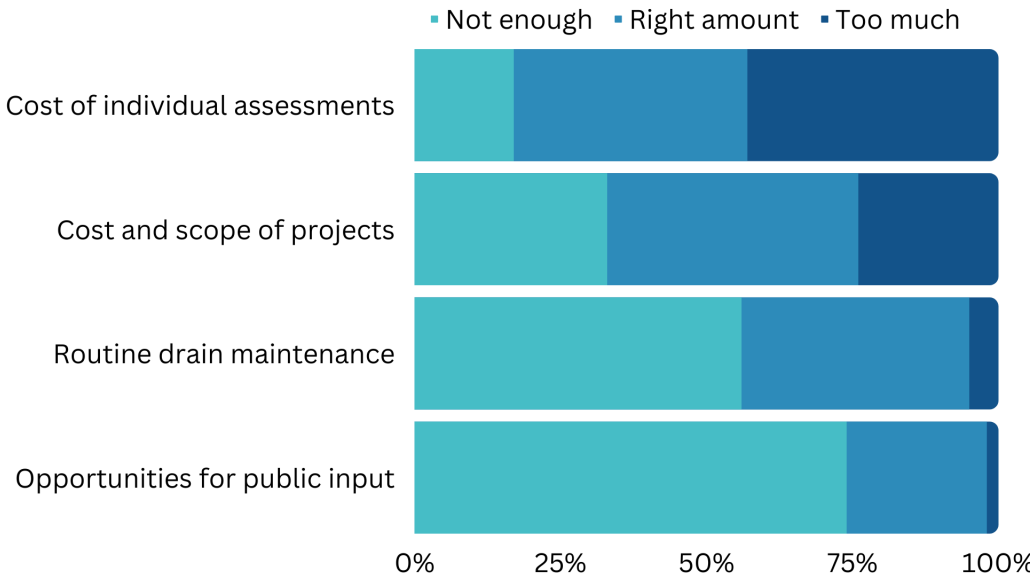

Figure 5. Opinions about drain projects

While opinions on the expense of drain projects were mixed, a wide majority of respondents (74%) thought that the amount of attention given to public input on drain project plans was insufficient. To a lesser extent, most respondents also believed that not enough attention was given to routine maintenance and repair (55%). Respondents' written comments provided further clarity about maintenance concerns and perceptions of fairness (Table 3).

Water Management Actions

We also asked respondents to evaluate how well several groups are doing to promote good water quality in the watershed, including residential homeowners, commercial landowners, farm operations, conservation groups, local government, and state or federal regulators (Figure 6). Respondents were asked to assign each group a letter grade, from "A" (5) through "F" (1).

Table 3. Respondent comments about drain projects

Maintenance Concerns	My property has a lot of springs, so digging anywhere changes the directions of water flow. After the county had dug the ditches on my road several years ago, I now get water in my basement when the water table is high - before that - I had a dry basement. Anderson drain goes through the farm and we pay $300.00 extra on our taxes for three years to clean the drain. So far this year they cleaned a little on the banks but had not been done in many years. I don't know how much money is set aside for drain projects. I can only say what we have been promised is only partially done and completed. It seems as if there is not much management where we live. Things get addressed only if we can't get down the road. Someone then complains and then it gets fixed. Ditches need to be dug out. Severe overflow of ditches during rain events causes flooding of fields, etc. We paid for a Hecksel drain. Crockery Creek Township installed it and we still have drain ditches that overflow every year in front of our property. We also have basement flooding, plumbing issues, and excess standing water in our backyard. We are in Muskegon County on the Sanford Drain where it joins the "Sanford" Creek. We own both sides for a little over 1/2 mile and would greatly appreciate help with eroding sites.
Fairness of Assessments	We attended several meetings where input was requested by community members. None except Crockery Lake residents was taken into consideration - our comments were brushed aside because they had already made up their minds prior to the meetings. Subsequently, we were charged an exorbitant amount of money to the Crockery Lake Drain Drainage District for a one-time assessment for our "private waterway" which is actually the county ditch! Ditches (county) in Chester Township do not drain properly - there is standing water. I was a bit sour about the price we paid for the drainage project almost immediately after we began to get settled in our new home, so that influences my opinions about that issue. I have met and talked with the Drain Commissioner & I think she has been doing a great job. She took over a mess and has been doing the hard work to improve the drainage. A+. I don't believe best science practices are occurring in regards to recent assessments levied. Many landowners and farmers were assessed extra amounts to create riffle beds when, I believe, it was not proven effective. Instead of trying it out in small sections and testing it (empirical data) it was just broadly done.

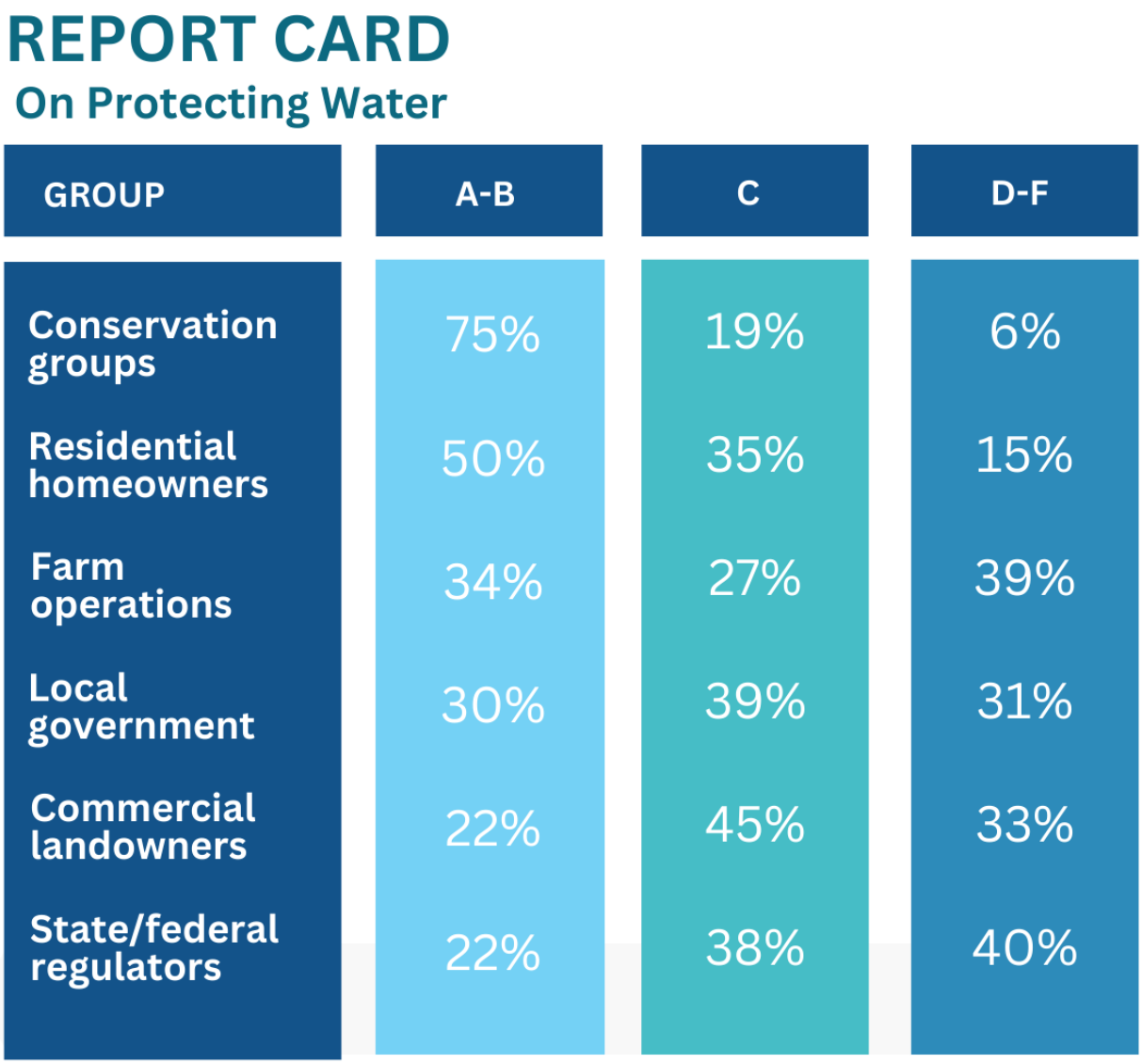

Figure 6. Evaluations of stakeholder contributions to water quality

Most groups earned a moderate performance evaluation, with mean scores falling roughly in the "B" to "C" range. Conservation groups received the most positive evaluation, and state and federal regulators received the most negative evaluation.

Open comments left on the back cover of the questionnaire booklet provided some context for the pessimistic evaluations of state and federal regulators (Table 4). Some watershed residents attributed a loss of aquatic organisms in Crockery Creek to a decades-old lampricide treatment conducted by the Michigan Department of Natural Resources (DNR). This experience, and others demonstrating a lack of competence on behalf of governing authorities, understandably undermined some residents' confidence in federal, state, and county officials. Other residents expressed general personal and political values that emphasized limited governmental interference in land management.

Table 4. Respondent comments about water management actions

Lack of Confidence in Officials	DNR has poisoned Crockery Creek in the 70's. Unexpectedly traveled to the Grand River, killing everything in Crockery Creek. They did the same thing a few years later. The pike etc. never came back like before the poisoning. Leatherback turtles never came back as well. So much for trying to plant trout in Crockery Lake... County replaced a one-lane bridge with a culvert (1980s). The culvert plugged up with washed road gravel, plugged it up solid, and re-routed the waterway going into Crockery Creek. Thanks government, I now have a muck area that no longer dries out. My township applies the salt-brine to the gravel roads. To keep dust down. During heavy rains, water flows over road. Guess where the salt-brine flows into? We no longer see or hear much of the birds and amphibians we heard in the 60's and 70's. I blame all of that on government... Leave the landowners alone and limit government stupidity that does more to destroy than help. I have witnessed fish kills... Great runs of steelhead and suckers still strong in spring. No small mouth bass, rock bass, northern pike. They were killed in the 80's from manure releases & lamprey controlled kill by DNR. These species were never replanted. The creek is dead. No fish, no life. Lived here for 73 years. The start was the fubar [sic] of the botched attempt to kill the eels. They killed everything. Now no money, no good fish out of private nurseries. It's a joke. Most farm fields are surrounded by a buffer zone, a bigger concern should be what the state does... The Grant septic tank Casnovia Twp. installed near the creek and wetland near Bailey.
Preference for Limited Governance	I am concerned with the potential for government mandates and regulations too fiercely/quickly or strictly coming into action that would affect our farmers' ability to produce foods as is being seen in other countries. Education, small changes, help/assistance could be a first step. I have a great respect for nature and generally practice responsible habits, but know that there is a balance to be struck. Any time governments or regulatory agencies become involved, the cost, complexity, and bureaucracy increases dramatically... The inefficiency of government is astounding. I have an idea (for govt.) Leave us alone - when we have trouble - actually do something! 1. No need to over fund 2. Do not overbuild 3. Over regulating hurts farmers and our economy.

Stewarding Crockery Creek

Michiganders have the unique distinction of living almost entirely within the drainage basin of one of the Great Lakes. This means that all the water flowing across Michigan land eventually makes it into 21% of the world's unfrozen freshwater supply, elevating the importance of protecting and improving the quality of inland waterways. And yet, water use and water impacts are things that almost no one thinks about in their day-to-day lives (Fishman, 2012). A second student researcher in the Social Science Lab who is pursuing a degree in environmental studies wanted to learn how residents feel about conservation of water resources and wetlands. We therefore presented respondents with a series of statements on these topics, to which they could select the extent that they agreed, from strongly disagree (1) to strongly agree (5).

Respondents overwhelmingly agreed that the quality of life in Crockery Creek watershed depends on good water quality, with average responses totaling 4.5 on a 5-point scale (Figure 7). Respondents were, on average, agreeable to changing property management practices to improve water quality, and they largely rejected the idea that protecting water quality should not interfere with economic development. Most agreed that they enjoy learning about wetlands and rejected the idea that wetlands should be converted to a more beneficial use. Respondents were neutral on their enthusiasm for visiting wetlands, which have a tough time competing with other, less buggy favorite places to visit.

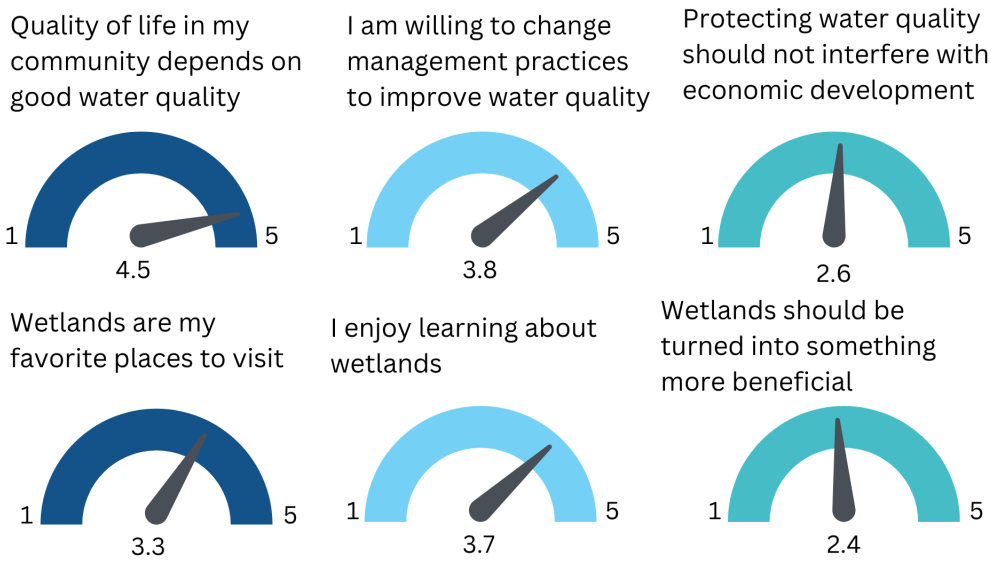

Figure 7. Opinions about water stewardship and wetland conservation - mean scores, "strongly disagree" (1) to "strongly agree" (5)

When asked which wetland conservation goals respondents thought should be prioritized (Figure 8), respondents were least likely to think that wetland conservation was important for helping the climate. This suggests that focusing on conservation benefits that promote fish and wildlife habitat, support outdoor recreation, and manage stormwater may be a more effective communication strategy than emphasizing benefits to the climate.

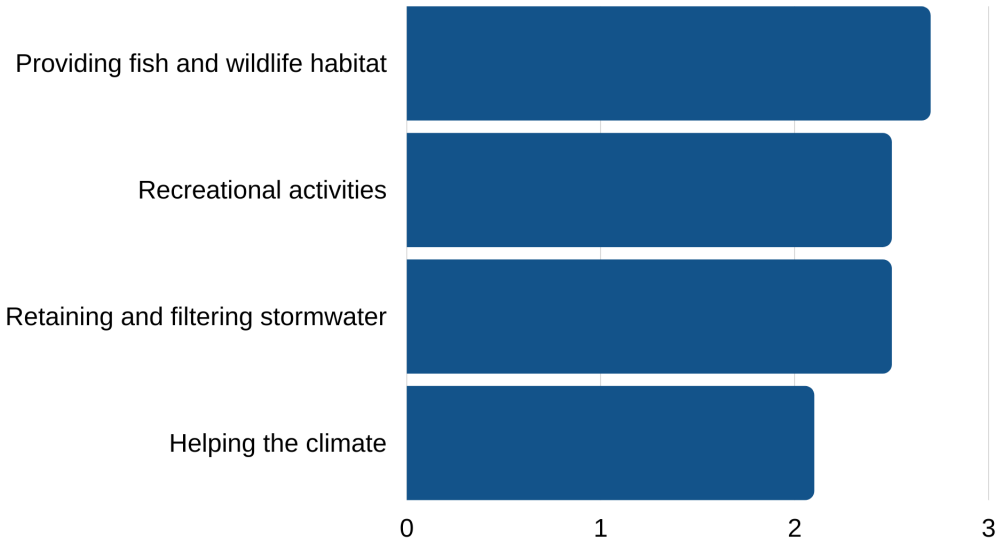

Figure 8. Wetland conservation priorities - mean scores, "not a priority" (1) to "high priority" (3)

Respondents noted their impressions of conservation opportunities and their interest in learning more about conservation techniques in written comments (Table 5).

Table 5. Respondent comments about conservation and stewardship

Interest in Conservation	Definitely interested in community projects involving ecosystem restoration and water resource management.
	I am not very knowledgeable about the "water shed" but I do care deeply about preserving land and natural resources.
	Born and raised in the UP. Conservation is in our blood. Have always been concerned about the abuse of our planet. It is our responsibility to save our resources and green/waterways. It's up to us.
	We endorse anything that protects and strengthens the watershed but don't have any background. We think a first step would be information and strategies for each household. As retirees we also do not have the finances to do what should be done. The "if it ain't broken, don't fix it" adage applies, but more so if we can't discern what IS broken.
	Water should be protected at all costs!! Good, clean.
	We hope that this survey helps improve and maintain the beauty and quality of Michigan's waters while also maintaining a hospitable, profitable, and sustainable condition for our farmers!
	When my grandfather purchased the home farm there were gullies my father could not see out of. He gradually fixed all of the erosion, and I still am very conscious of erosion. We have maintained waterways, set backs (buffer strips), and crop rotation to control erosion.
	I do plant pine and trees to help with wind, noise, wildlife.

Crockery Creek Water Quality

Non-point source pollutants are a vexing problem for watersheds because they come from diffuse sources and are carried by precipitation into a common drainage basin (U.S. EPA, 2022). We wanted to know more about which specific threats to water quality residents are most concerned about so that we can develop communication strategies that focus messaging on who and what is most important.

With these objective in mind, we asked survey respondents to evaluate how severely they believed a variety of water impairments, sources of pollution, and consequences of poor water quality may be impacting Crockery Creek watershed. For each item, respondents were asked to rank the level of severity on a four-point scale, from "not at all a problem" (1) to "severe problem" (4), and they could also select that they "don't know."

Most impairments, their sources, and their consequences were evaluated as being slight (2) to moderate (3) problems on average (Figure 9). Nutrients from fertilizer and their sources were seen as somewhat more problematic than other impairments, as were drinking water quality and loss of fish. However, differences in the midpoint values across items were slight and did not reach the threshold of statistical significance, ranging from 2.5-3 on most items.

Given these small differences in the perceived severity of individual pollutants and their sources, we learned more by examining which impairments respondents "don't know" much about (Figure 10). Sixty percent of respondents did not know whether or how severely

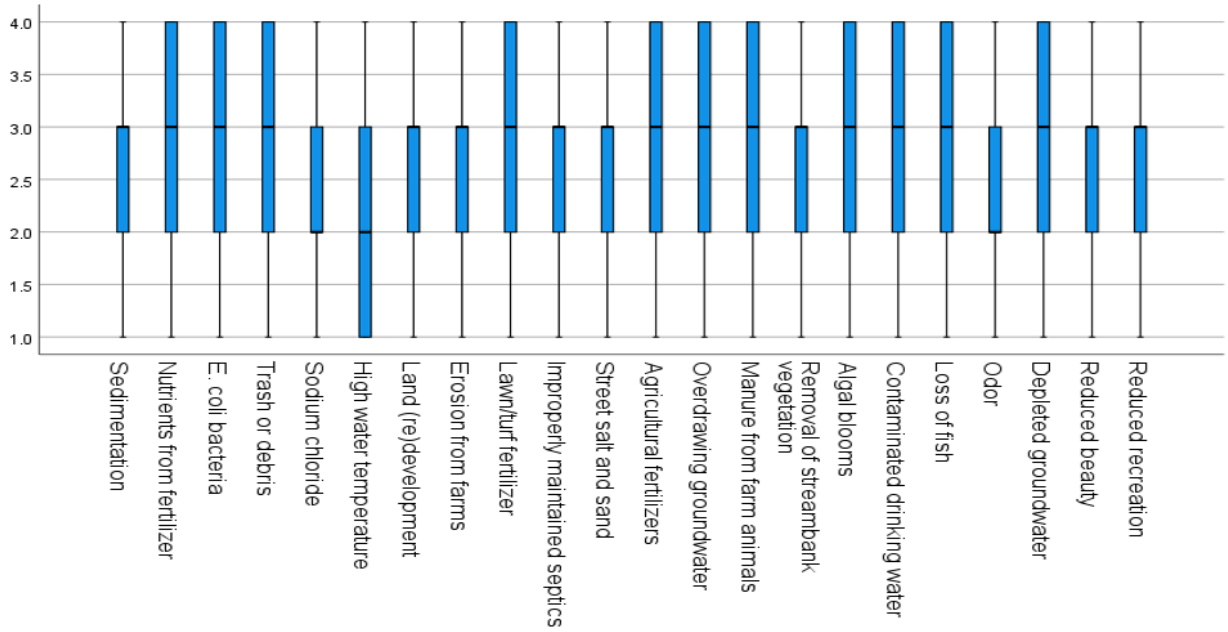

Figure 9. Average impressions of water pollutants, sources of pollution, and consequences of pollution

sodium chloride pollution may be impacting the watershed, and approximately 40% were unsure about high water temperature and *E. coli* pollution, suggesting that there are substantial knowledge gaps about these threats to water quality in Crockery Creek. The proportion of respondent who "don't know" how much each source contributes to water pollution in Crockery Creek watershed was lower than those who "don't know" about the severity of individual impairments. Consistent with the previous set of items, groundwater depletion (a source of sodium chloride contamination), removal of streambank vegetation (a source of high water temperature), and failing septic systems (a source of *E. coli* pollution) stood out as sources that respondents were significantly less aware of. It follows that these will be important topics for future outreach and communication.

The proportion of respondents who "don't know" about consequences of poor water quality was lower than the previous items, with one-quarter of respondents being unsure about algal blooms, drinking water quality, loss of fish, and depleted groundwater, and even fewer (12-20%) being unsure about the severity of aesthetic problems and reduced recreational opportunities.

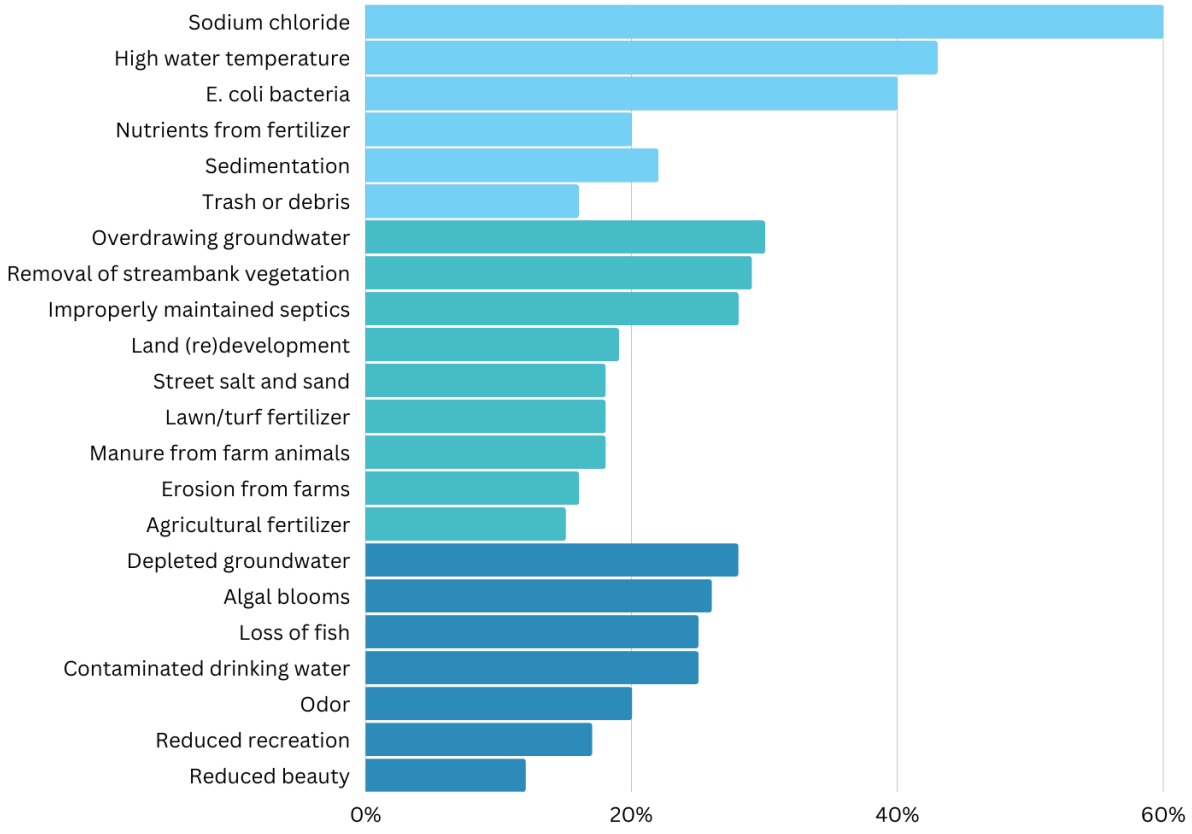

Figure 10. Percent of respondents who "don't know" about water pollution

Concerns about the loss of aquatic biodiversity, farming practices, drinking water quality, and groundwater depletion were noted in open comments left on the back cover of the questionnaire booklet. Many respondents believed that land application of dairy manure is harmful to watershed health, with several noting the destruction caused by an accidental manure spill a few year ago (2019). Table 6 includes comments from respondents by topic.

Table 6. Respondent comments about water quality concerns

Farming Practices	I am concerned about the amount of manure that is making it in ditches and streams around the large dairy farms and farmers putting manure on before rains and on frozen fields... I think the EPA & DEQ need higher fines. Also, too many animals on CAFOs = too much manure/acre.
	I see the large farmers haul lots of manure and cover fields thick. I know they need to get rid of it but it is still a concern.
	I would like to see all commercial dairy operations stopped. They tear up our roads, pollute our creeks and streams, ponds, lakes, etc. We should go back to the small time dairy practices.
	Farmers should NOT be allowed to apply "sludge" to fields. They get sludge from business, of which it is not known what contaminants are in the sludge. We feel it hurts our water supply very much.
	One source of pollution I witness every year is liquid manure runoff into the tributaries and drainage ditches. For example every March, six inches of sludge is applied to fields sloping into the ditches. The thawing temps and rain wash all the liquid manure into the waters. Drains and tributaries become open manure drainage into C. Creek. It's disgusting and no agency or person is monitoring this abuse.
	Some issues I have, I worry about my well water becoming contaminated from all the chemicals the farmer uses for his fields. Then it runs off into my front watershed/ditch from his fields when it rains. He also uses manure from his livestock to put on his fields.
	I have been actively working with the county, township, and MDARD regarding a neighbor with NO manure management and leaving excessive piles of dead animals (30+ cattle at times) in the pastures.
	I have been told that [a nearby farm] lost all his cows but two. Instead of disposing of them properly he dumped them behind his farm somewhere. Also same farm has a manure pile on the east side of the barn. Every time we get a rain it leaches into the ditch there. I believe in the "Right to Farm" but when and where do we hold the farmers accountable.
	My biggest concern around here is the manure trucks that run year round. It is hard for me to believe that none of the manure ends up in the watershed.
	The factory farms, orchards, and corporations are what are killing Crockery Creek.
	The widespread application of liquefied and solid manure on cultivated fields has to lead to the degradation of the water quality in the watershed... I've witnessed the spray application of herbicides and pesticides onto the soil or crop plants for 18 years... Some of these chemicals must end up in the drains, creeks, and lakes in the watershed, degrading these precious resources.

Loss of Aquatic Organisms

Our family loves our property - especially the creek out back. Since we've lived here the creek has been contaminated to the point of all loss of life. We documented with pictures and contacted the DNR just to get no response back. In one photo I remember counting a few years ago dozens of fish, crayfish, frogs all belly up.

Over the years, their have been major changes in our creek. Very few spring run suckers and northern pike. Black snakes that were prevalent, are missing now. General minnow population is low.

I've lived on Crockery Creek for 45 yrs. The fishing opportunities keep dwindling as more and more sediment fills the creek bottom and covers rocks, reducing aquatic invertebrates... The fishery just keeps falling off.

Drinking Water Quality

I am concerned about the safety and quality of my well water for drinking, very high iron content.

I live in Chester Township near Conklin. I have a very deep well and the water is not very good and needs to be treated, costing a lot of money.

Sodium chloride in the groundwater is a critical issue that needs to be addressed much more energetically. Homeowners with wells in areas with higher than acceptable sodium chloride levels need help and education not currently provided.

We have high levels of iron and calcium from the looks of our water and discoloration. This began in 2003 when a deeper well was installed. We live in an ag area of Chester Township.

Manure Spill

In July 2019... a gray smelly slime from a farm manure spill upstream killed every living thing - cray fish, frogs, fish, water bugs, etc. Now for the first time since then, the creek is fairly clear again and the fish are slowly coming back but every time it rains we get farm manure runoff and the water turns a grayish brown. In the old days, it turned a sandy brown after rain or spring high water. The main problem as I see it is liquid manure runoff.

A few years ago a major manure spill occurred at the headwaters of Crockery Creek. It devastated the fish population. We had to stay away from the creek for a long period of time. I was told that the farmer felt bad and was fined, but this all seemed to be kept quiet. I think practices/ measures should be put in place to help increase the chances that this does not occur.

A few years ago a farm had a manure spill for days and never received any costs for doing so. The habitat was completely wiped out frogs, fish, etc., all dead. They never had to replant the stream or be held accountable and to me it's sickening. It will take years to overcome this and nothing was done.

Over the past 20 years, there have been multiple farm related releases in the drain/creek... Visual fish kills happened due to oxygen depletion.

Groundwater Withdrawals

I am concerned about the number of wells being used and drilled by farmers, especially fruit farmers. I have friends/neighbors who have had to replace their wells due to failure after ag wells were drilled.

I have concerns about the large sprinkler systems utilized by the farms in the area. They must be depleting the ground water supply, and we all use wells, no city water, in our area.

This is a dry year and we could lose the use of our wells! Which has never happened!

My concern is my pond. The blueberry farm next door waters their crops and when they do, my pond gets progressively lower and lower. Looks like a mud puddle by August :(I support farming, but worry about the quality of my pond and the fish, fowl and animals that live in, on, or near it.

Overuse of groundwater is another critical issue that seems to have been allowed to lapse into the background. Both residential and agricultural groundwater users need to be educated about this issue and recruited to help with solutions.

The depletion of the water table is of great concern.

The farms in my area pump a lot of water during the summer months.

Too much irrigation and wells being used for apple tree watering. Any regulations on this? Doesn't this use aquifer water - our drinking water? Chester Township, why all the newly built houses? They all use wells?

Other Concerns

Curious about the affect local cemeteries (especially St. Michael's) have on the surrounding water. Embalming fluids and synthetic materials (clothes, caskets, etc.) can't be great for the water?

I am concerned about the effect of the landfill in Coopersville on the groundwater supply.

I'm quite concerned about the salt that's ending up in the water due to use/overuse of road salt.

We love to fish and swim in the creek, however, lately there is white foam buildup in certain areas.

Aging city systems contribute to poor water management for all of those that try so hard to conserve.

The amount of people moving to West Michigan, sucking the resources dry is disheartening. My family has been in Muskegon County since the mid 1800s and European settlers have rendered this area unrecognizable and undesirable.

The widespread, heavy application of NaCl onto roads, parking lots, sidewalks, etc., in anticipation of and to deal with snowfall has to lead to significant degradation of water quality in the watershed.

Property Management Practices

The social indicators planning and evaluation system (SIPES) was designed to learn how the people of the Great Lakes value and impact the global freshwater treasure they live within (Genskow and Prokopy, 2011). We therefore asked survey respondents about best management practices (BMPs) related to septic systems, gardens, streambanks, cropping systems, and manure from farm animals, as well as the things that get in their way of using conservation practices. Familiarity with each BMP was scored on a four-point scale, from "Never hear of it" (1) to "Currently using it" (4). Limitations to using each practice were also scored on a four-point scale, with respondents selecting how much each limitation was a problem for them, from "Not at all" (1) to "A lot" (4). Sections on septic systems, gardens, and streambanks were applicable to most respondents, while a smaller selection of respondents managed farm animals and cropping systems.

Septic Systems

The average age of septic systems reported by survey respondents was 23 years. Roughly one in four survey respondents (26%) did not know how old their septic system was, and another quarter of respondents (24%) reported having systems that are more than 30 years old, the industry-suggested lifespan of a septic system. The range of septic system ages was very large, from brand new systems (less than one year old) to a 100-year-old system.

Regarding best practices for septic maintenance (Table 7), 59% of respondents reported having their septic tank pumped every 3-5 years, as is recommended by industry professionals. However, 46% have never had their septic tank and field system inspected by a professional.

Respondents were most familiar with checking the cover of their septic tank for proper closure and checking their system's drain field for wet spots (Table 7). Respondents were somewhat less familiar with the importance of checking the drain field for tree roots. Just over half (51%) had never heard of checking the effluent filter on their system for clogs.

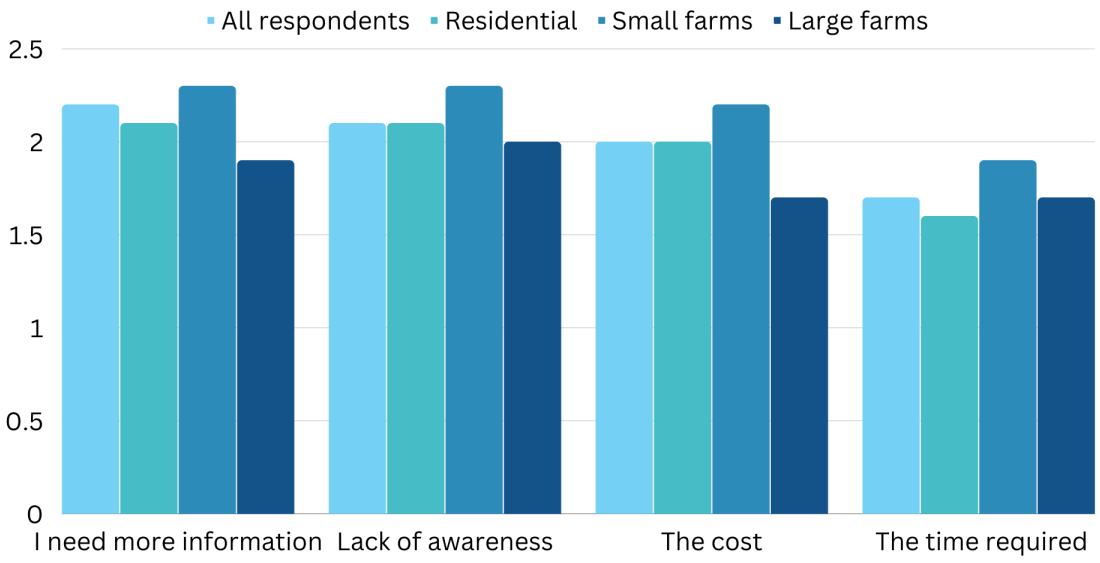

Figure 11. Factors limiting use of BMPs in septic systems - mean scores, "not at all" (1) to "a lot" (4)

Table 7. ANOVA results, familiarity with septic BMPs by property type
"Never heard of it" (1) to "Currently using it" (4)

Variable	Overall Mean (SD)	Property Type	*n*	Mean	Std. Dev.	ANOVA	
Pumping frequency						**F**	***p***
	2.3 (0.9)	Residential	158	2.4	1.0	.445	.635*
		Small farm	94	2.3	0.9		
		Large farm	45	2.2	1.0		
Inspection frequency							
	1.2 (1.3)	Residential	155	1.3	1.3	1.172	.311*
		Small farm	94	1.3	1.3		
		Large farm	45	1.0	1.2		
Checking cover for closure							
	2.8 (1.3)	Residential	160	2.7	1.3	1.303	.273*
		Small farm	96	2.9	1.3		
		Large farm	45	3.0	1.2		
Checking drain field for wet spots							
	2.8 (1.3)	Residential	158	2.6[a]	1.3	5.078	.007
		Small farm	97	2.9[a,b]	1.3		
		Large farm	45	3.2[b]	1.1		
Checking drain field for roots							
	2.3 (1.2)	Residential	159	2.2[a]	1.2	4.714	.010
		Small farm	96	2.3[a,b]	1.2		
		Large farm	45	2.8[b]	1.2		
Checking effluent filter for clogs							
	2.0 (1.2)	Residential	157	1.8	1.2	3.236	.041*
		Small farm	94	2.2	1.2		
		Large farm	45	2.2	1.3		

[a,b] Different superscripts indicate statistically significant means differences between groups.
* Statistically significant differences between groups not detected.

We examined septic maintenance practices by property type using Analysis of Variance (ANOVA) to compare the mean scores of respondents with residential properties, small farms, and large farms (Table 7). Statistically significant differences were apparent only between residential respondents and large farmers on familiarity with checking the drain field for wet areas and roots, with residential homeowners reporting significantly lower levels of familiarity with these practices than farmers with large operations in the watershed.

Concerning factors that limit their septic system maintenance, lacking information, awareness, and funds were somewhat more challenging than having enough time (Figure 11). This was true for all respondents regardless of property type and will be a key area for outreach as exurban development grows. One respondent noted, "I had no idea septic systems required maintenance because my entire adult life has been spent in rentals or on city water."

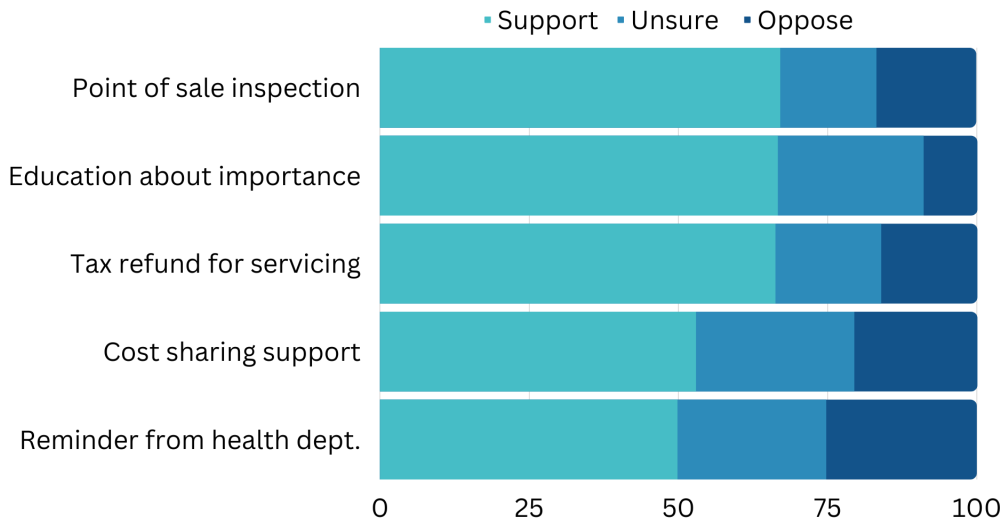

Figure 12. Support for actions to encourage regular septic servicing

We also asked survey respondents whether they would support, oppose, or were unsure about five policy actions to encourage watershed residents to service their septic systems regularly (Figure 12). Overall, there was a high degree of support for all policy actions, with more than half of respondents supporting each and two-thirds supporting more education, a required inspection when selling a home, and a tax refund for servicing systems every 3-5 years. A larger proportion of respondents opposed receiving a reminder from the health department (25%) and cost share assistance to help cover expenses (21%). Mean scores were similar across property types, although large farmers were slightly less likely to support tax refunds than residential homeowners and small farmers. Further research and public discussion are needed to evaluate why respondents supported or opposed each action, including verification that respondents understood the implications of each policy action. However, many Crockery Creek residents are generally supportive of policy actions that encourage regular septic servicing in the watershed.

Gardens

Whether they owned residential properties, small farms, or large farms, survey respondents were enthusiastic gardeners. Eighty-four percent (n=271) reported managing gardens on their property. Among the water quality BMPs asked about in the survey (Table 8), reducing water wastage by watering outside of peak evaporation times (early in the morning or at dusk) was the most reported practice, with 82% of respondents with gardens currently doing this. Twenty-seven percent of respondents are currently using phosphate free fertilizer and conducting soil tests, and 18% harvest rainwater in rain barrels. Respondents were least familiar with using rain gardens for stormwater management. Only 7% of respondents are currently using this practice, and 42% had never heard of it.

Table 8. ANOVA results, familiarity with gardening BMPs by property type
"Never heard of it" (1) to "Currently using it" (4)

Variable	Overall Mean (SD)	Property Type	*n*	Mean	Std. Dev.	ANOVA	
Capturing rainwater in barrels						**F**	***p***
	2.9 (0.7)	Residential	120	2.9	0.7	.238	.788*
		Small farm	81	2.9	0.7		
		Large farm	32	3.0	0.8		
Using phosphate free fertilizer							
	2.7 (1.0)	Residential	110	2.8	1.1	.916	.402*
		Small farm	71	2.5	1.1		
		Large farm	36	2.8	0.8		
Creating a rain garden							
	1.9 (1.0)	Residential	114	1.9	0.9	.580	.561*
		Small farm	76	2.0	1.0		
		Large farm	33	2.1	0.9		
Conducting soil tests							
	2.9 (0.8)	Residential	112	2.6[a]	0.8	15.235	<.001
		Small farm	82	2.9[a]	0.8		
		Large farm	39	3.5[b]	0.8		
Watering early morning or at dusk							
	3.8 (0.5)	Residential	128	3.8	0.5	.146	.864*
		Small farm	86	3.7	0.6		
		Large farm	37	3.8	0.5		

[a,b] Different superscripts indicate statistically significant means differences between groups.
* Statistically significant differences between groups not detected.

Usage of BMPs in gardens was similar across property types, except for soil testing. Most respondents were somewhat familiar with or knowledgeable about soil testing, but use of this practice was significantly higher on large farms (64% currently using) than on small farms (24% currently using) or residential properties (15% currently using).

When asked about factors limiting use of water quality BMPs in their gardens, respondents evaluated the time and expense of using BMPs, and lacking equipment and knowledge as "somewhat" problematic ("2" on a 4-point scale) (Figure 13). No single factor stood out as a substantial barrier, but small farmers reported experiencing slightly and significantly higher levels of limitation concerning having the time, money, and equipment to use each practice than did large farms or residential property owners. This suggests that small-scale operators may experience a particular pinch as they try to expand production beyond a few tomato plants but remain less professionalized and profitable than large-scale operations, highlighting unique vulnerabilities among this group of landowners in the watershed.

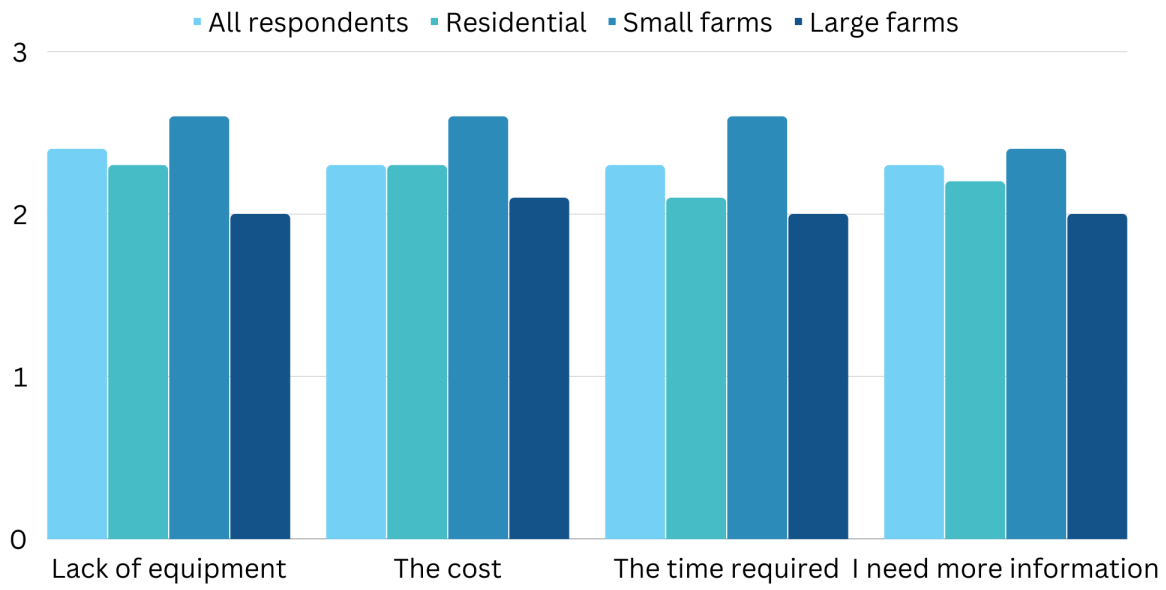

Figure 13. Factors limiting use of BMPs in gardens - mean scores, "not at all" (1) to "a lot" (4)

Streambanks

Riparian property owners had a particularly high interest in completing the survey. Sixty-four percent of respondents (n=206) reported having a stream, drain, lake, wetland, or some other waterway on or bordering their property (Table 9). Fifty-five percent of residential property owners have riparian zones on their properties (n=91), compared with 72% of small farms (n=71), and 94% of large farms (n=44). Most residential respondents and small farmers described the waterways on their properties as creeks or wetlands, while large farmers were the most likely to describe their waterways as agricultural drains.

Table 9. Characteristics of waterways by property type

	Creek (n)	Drain (n)	Lake/Pond (n)	Wetland (n)	Other (n)
Residential	51	15	17	25	10
Small farm	41	21	19	21	6
Large farm	19	35	12	16	2

Survey respondents with waterways were asked about their riparian zone management practices and factors limiting their ability to implement BMPs. Across landowner types, protecting streambanks and shorelines with vegetation and improving wildlife habitat were the most reported BMPs in use in the watershed (Table 10). Large farms were significantly more likely than residential property owners to report (re)vegetating streambanks and maintaining a six-foot buffer along waterways, and both small and large farmers were more likely to report improving wildlife habitat than were residential property owners.

Watering livestock from an off-stream source and reinforcing stream crossings were not applicable to residential properties, which by definition do not have farm animals or cropping systems to maintain with heavy machinery. We therefore used T-tests to compare the mean

Table 10. ANOVA/T-test results, familiarity with streambank BMPs by property type
"Never heard of it" (1) to "Currently using it" (4)

Variable	Overall Mean (SD)	Property Type	*n*	Mean	Std. Dev.	ANOVA/T-Test	
Protecting banks/shore with vegetation						**F**	***p***
	3.3 (1.0)	Residential	76	3.1[a]	1.1	4.520	.012
		Small farm	62	3.3[a,b]	1.0		
		Large farm	42	3.7[b]	0.7		
Maintaining buffer (6+ foot) along water							
	3.0 (1.2)	Residential	74	2.7[a]	1.3	5.831	.004
		Small farm	58	3.1[a,b]	1.2		
		Large farm	38	3.6[b]	0.9		
Improving habitat for wildlife							
	3.3 (1.0)	Residential	81	3.0[a]	1.1	4.603	.011
		Small farm	64	3.5[b]	0.9		
		Large farm	41	3.5[b]	0.8		
Water livestock off-stream						**T**	***p***
	2.8 (1.2)	Residential	--	--	--		
		Small farm	33	2.8	1.0	-1.711	.093*
		Large farm	19	3.3	1.0		
Reinforcing stream crossings							
	2.7 (1.2)	Residential	--	--	--	-1.712	.092*
		Small farm	35	2.7	1.0		
		Large farm	25	3.2	1.1		

[a,b] Different superscripts indicate statistically significant means differences between groups.
* Statistically significant differences between groups not detected.

scores of small farms and large farms on these items. Although large farms reported using these BMPs at a slightly higher rate than small farms, this difference was not statistically significant and is likely explained by the greater applicability of these practices to large operations compared with small farms.

The expense of riparian BMP implementation, access to equipment, knowledge about practices, and having enough time to implement BMPs were each evaluated as "a little" bit of a problem to using riparian BMPs (Figure 14). Limiting factors were equally problematic across landowner types, with no landowner group reportedly experiencing significantly more or less of each limitation than other groups.

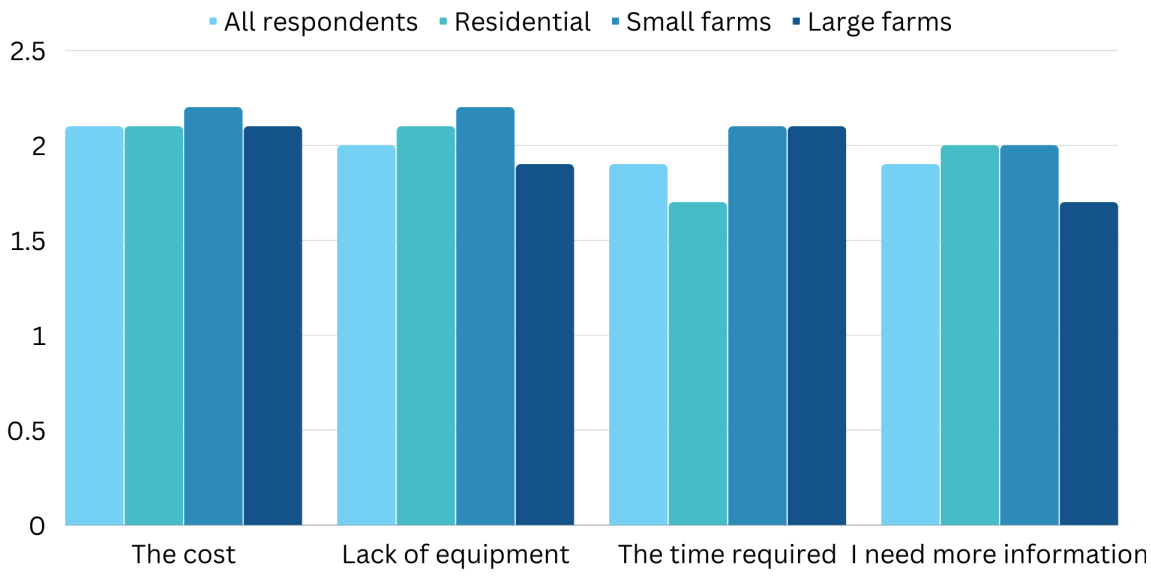

Figure 14. Factors limiting use of BMPs along streambanks - mean scores, "not at all" (1) to "a lot" (4)

Cropping Systems

Twenty-three percent of respondents (n=75) reported having cropping systems on their property. Thirty-six of these were classified as small farms (48%), and 39 were large farms (52%). Small farmers were more likely to report raising canning crops and fruit, while large farmers were more likely to report raising commodity crops and hay (Table 11). The range in the number of acres planted in each type of crop was much greater on large operations than on small farms, with five respondents managing over 1,000 acres of farmland. Survey respondents with cropping systems were asked about their nutrient and water quality management practices and factors limiting their ability to implement BMPs. We used T-tests to compare the average rates of use between small and large farms and assess the statistical significance of differences.

Table 11. Characteristics of cropping systems by property type

Small Farms

	Corn	Beans	Canning	Hay	Fruit	Small grains	CRP
# of farms	8	4	9	15	14	4	2
Acres	1-38	.5-7	.5-7	.5-26	.5-7	.5-33	2-40
Mean (SD)	12 (14)	2 (1)	2 (2)	10 (7)	2 (2)	15 (16)	21 (27)

Large Farms

	Corn	Beans	Canning	Hay	Fruit	Small grains	CRP
# of farms	25	20	3	25	5	12	2
Acres	10-1,400	6-424	1-1,500	1-500	5-1,100	1-300	45-55
Mean (SD)	228 (340)	118 (121)	524 (846)	87 (129)	306 (475)	85 (89)	50 (7)

Table 12. T-test results, familiarity with cropping system BMPs by property type
"Never heard of it" (1) to "Currently using it" (4)

Variable	Overall Mean (SD)	Property Type	*n*	Mean	Std. Dev.	T-Test	
Conducting soil tests						T	*p*
	3.4 (0.8)	Small farm	34	3.1	0.9	-3.741	<.001
		Large farm	38	3.7	0.7		
Using a nutrient mgmt. plan							
	3.0 (1.1)	Small farm	33	2.7	1.1	-2.640	.010
		Large farm	35	3.4	1.0		
Using reduced tillage							
	3.3 (0.9)	Small farm	29	2.9	0.9	-3.771	<.001
		Large farm	34	3.7	0.7		
Planting cover crops							
	3.2 (0.9)	Small farm	30	3.0	0.9	-1.477	.145
		Large farm	34	3.3	0.8		
Using a grassed waterway							
	3.1 (1.1)	Small farm	24	2.6	1.2	-2.965	.005
		Large farm	37	3.5	0.9		
Applying treatments with precision technology							
	2.9 (1.1)	Small farm	26	2.5	1.1	-2.753	.008
		Large farm	36	3.3	1.0		

Large farmers reported using most cropping system BMPs at a higher rate than small farmers (Table 12). T-test results confirmed that these differences in BMP adoption were statistically significant and robust between groups for all BMPs except cover crops, which are being implemented at similar rates on small and large farms. Among survey respondents operating large farms in the watershed, conducting soil tests, using no-till or reduced tillage, using grassed waterways to control erosion, and using a nutrient management plan were widely reported as commonly used practices, with adoption rates ranging from 68-84% on large farms. In contrast, roughly one-third of small farms reported using each BMP. On large farms, use of precision technologies (such as variable rate application technology or infrared sprayers) and cover crops lagged compared to other BMPs, with approximately half of large farms reporting using these practices.

Small farmers reported moderate levels of familiarity with each practice, with very few indicating that they had "never heard of" a practice or that it was inapplicable to their operation. Lack of information was also the least limiting factor for both small and large farmers (Figure 15), suggesting that knowledge alone is not the most substantial barrier to adopting conservation management techniques in cropping systems. While all limiting factors were evaluated as only "somewhat problematic," lacking equipment was the largest barrier to implementing cropping system BMPs for small farmers, and the difference in mean scores between small and large farmers was statistically significant only on this item.

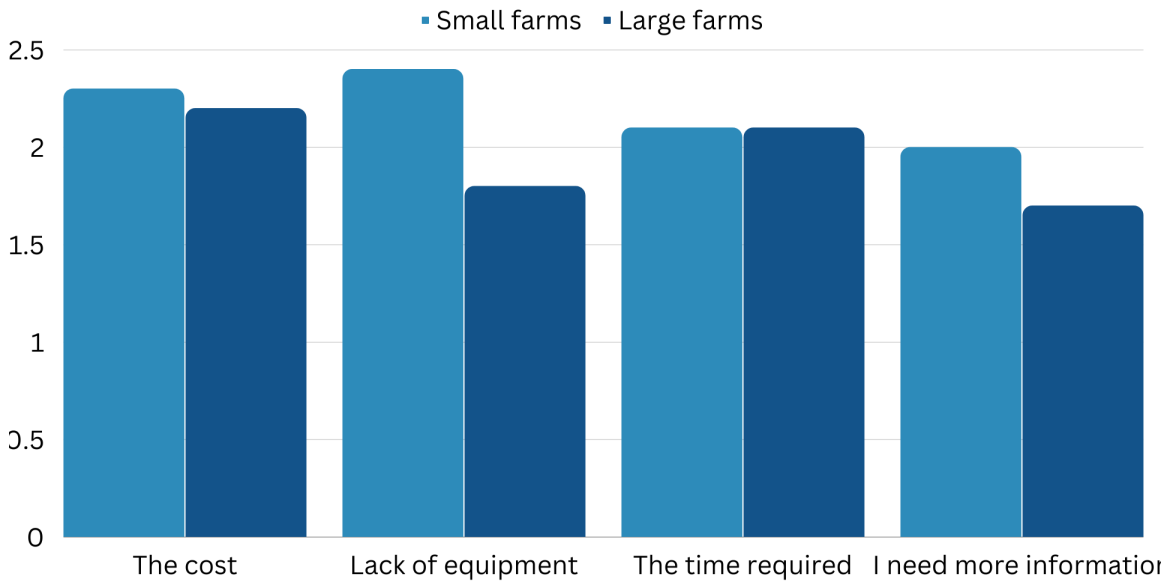

Figure 15. Factors limiting use of BMPs in cropping systems - mean scores, "not at all" (1) to "a lot" (4)

A few respondents left suggestions for improving drain tiling in cropping systems. One wrote, "If farmland is tiled correctly more water percolates through the soil, resulting in less runoff. Farmers should be given more assistance and less grief when looking to tile farmland." Another suggested, "Field tiling is wasting good water... Retention ponds should be considered to help keep water on site for irrigation or to simply soak in and help recharge the aquifer."

Farm Animals

Thirty percent of respondents (n=98) reported having farm animals on their properties (Table 13). Seventy-four of these were classified as small farms, and 24 were large farms. Our respondents included a few large cattle and hog operations, with the range in number of animals being much greater on large farms than small farms. However, small farms reported a wider variety of all types of animals and were particularly more likely to report having poultry, horses, goats, and rabbits than were large farms.

Table 13. Characteristics of farm animals by property type

Small Farms						
	Cattle	**Goats**	**Hogs**	**Horses**	**Poultry**	**Rabbits**
# of farms	14	11	11	23	49	12
# of animals	2-25	1-10	2-20	1-12	2-200	1-2
Mean (SD)	9 (7)	3 (3)	5 (6)	3 (2)	18 (29)	1 (.4)
Large Farms						
	Cattle	**Goats**	**Hogs**	**Horses**	**Poultry**	**Rabbits**
# of farms	13	4	5	3	14	1
# of animals	1-1,800	1-19	1-800	2-8	2-150	1-1
Mean (SD)	253 (500)	7 (8)	165 (355)	4 (3)	34 (43)	1 (1)

Table 14. T-test results, familiarity with manure BMPs by property type
"Never heard of it" (1) to "Currently using it" (4)

Variable	Overall Mean (SD)	Property Type	*n*	Mean	Std. Dev.	T-Test	
Stockpiling on the ground						T	*p*
	3.2 (0.9)	Small farm	49	3.2	1.0	-.325	.746
		Large farm	23	3.3	0.8		
Dry stacking on concrete							
	2.5 (0.8)	Small farm	39	2.3	0.7	-2.752	.008
		Large farm	19	2.9	0.9		
Using a lagoon or digester							
	2.5 (0.9)	Small farm	32	2.2	0.8	-3.094	.003
		Large farm	18	2.9	0.9		
Composting before spreading							
	3.2 (1.0)	Small farm	58	3.2	1.0	.102	.919
		Large farm	22	3.2	0.9		
Avoiding land application in fall season							
	2.7 (1.2)	Small farm	46	2.6	1.3	-1.565	.123
		Large farm	20	3.0	0.7		

Survey respondents with farm animals were asked about their manure management practices and factors limiting their ability to implement BMPs. By definition, residential properties do not have farm animals and are therefore not included in this analysis.

On both small and large farms, stockpiling manure on the ground and composting manure before spreading were the most common methods of managing animal manure (Table 14). However, only large farms have invested in sophisticated structures, such as concrete slabs for dry-stacking manure (32%), and manure lagoons and biodigesters (28%). Thirty-nine percent of small farms and 27% of large farms reported avoiding fall manure applications, suggesting that storage capacity on farms, and large farms in particular, is largely inadequate to avoid fall applications. Several survey respondents noted that the manure management strategies included in the survey were inapplicable to operations with pastured animals, where manure is not accumulating in a small area and can be worked back into the soil organically to improve nutrient content.

Equipment, expense, time, and information were, on average, reported to be only "a little" bit of a limitation to using manure management BMPs on farms (Figure 16). Large farmers were slightly less likely to report that each of these factors limited BMP use than small farmers, although most differences were not statistically significant. One exception was access to equipment, which was significantly more of a limitation for small farmers than large farmers. Twenty-one percent of small farmers reporting that this is "a lot" of the problem limiting their use of best practices, compared to only 13% of large farmers. Large farmers were particularly confident that they have the information they need to make effective manure management decisions, with 74% reporting that needing more information was "not at all" a factor limiting BMP use, compared to 51% of small farmers.

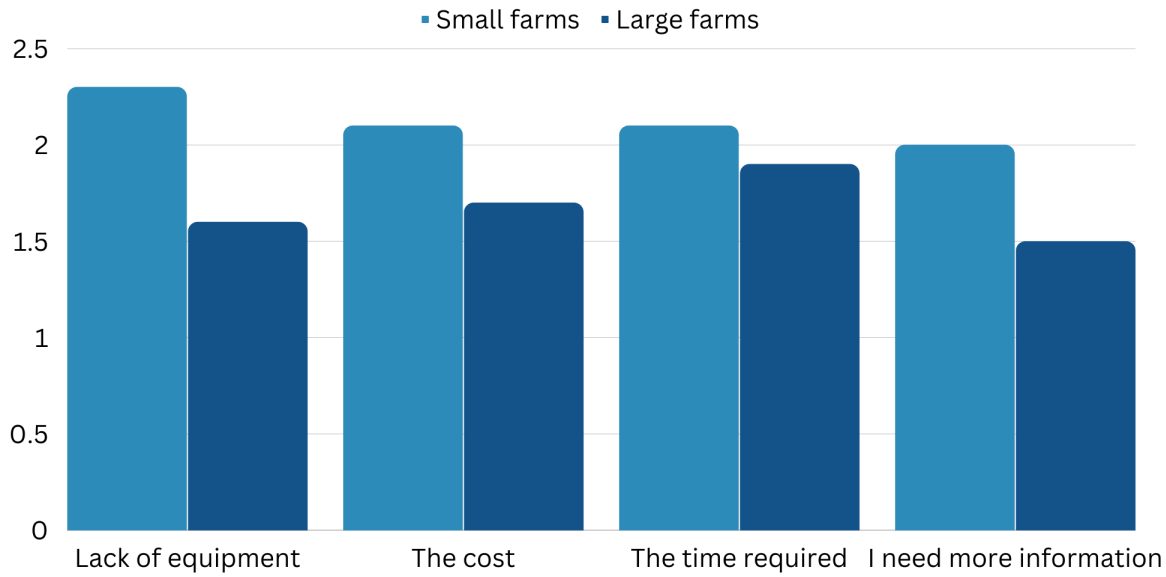

Figure 16. Factors limiting use of BMPs in manure management - mean scores, "not at all" (1) to "a lot" (4)

Learning about BMPs

For each BMP, we also asked respondents which sources of information they consult to learn about management practices. Consistently across all items, the importance of conversations with others stood out as the primary way respondents have learned about each BMP. Approximately two-thirds of respondents reported learning about BMPs related to septic systems, gardening, stream banks, farm animals, and cropping systems through word-of-mouth. Who are residents talking with? Family members were frequently listed as important sources of information, with fathers and grandparents referenced most. Regarding septic system BMPs, septic servicers were listed as an important source of information by a dozen respondents, who noted that they talk with their technician when they are out pumping the tank.

The second most common source of information consulted was the Internet, with 30-50% of respondents indicating they get online when they need to learn something about property management. MSU Extension was an important source of information for those with cropping systems. Approximately one-third of respondents indicated that publications specific to gardening, livestock, conservation, etc., were important sources of information about each BMP, and many noted that they have received valuable information from their county Conservation District or their local Conservation Club.

Finally, respondents reported that experiential knowledge, or learning by doing, is a primary way they have learned about BMPs. "Common sense" was frequently written in as an "other" source of information for each BMP. The life experience gained by growing up on a farm, working in a relevant industry or for a conservation organization, and learning from dealing with problems on one's property are valuable ways that respondents have accumulated information over the years.

Conclusions and Recommendations

Crockery Creek watershed residents are outdoor enthusiasts. From hunting and fishing to animal husbandry and farming, Crockery Creek residents have a deep investment in natural resources and their stewardship. It follows that communications about conservation goals should focus on benefits of interest to the community, such as supporting healthy fish and wildlife habitat, or efficiently managing land and water for crops and animals. Given the importance of word-of-mouth as a primary source of circulating information in the watershed, holding public events and working one-on-one with landowners will be important methods for communicating with Crockery Creek residents. Public events are also valuable for building relationships with residents that restore confidence in management agencies.

Overall, Crockery Creek Speaks respondents evaluated most water impairments as slight to moderate problems in the watershed, indicating that residents are not overly concerned about any single water pollutant. Residents are getting the message about negative impacts associated with lawn and agricultural fertilizers, with many understanding that this is a common source of water pollution. However, there is less awareness about pollution related to groundwater depletion, which causes sodium chloride contamination; improper septic system maintenance, which causes *E. coli* pollution; and removal of shady streambank vegetation, which raises water temperature and increases sediment loading, compromising cold water fisheries. Given the regional significance of problems associated with each, these three topics will be important focal points for future communication strategies.

Reported BMP usage reinforced the importance of outreach topics about septic and riparian zone maintenance, with reported usage of these BMPs being lower on residential properties and small farms than on large farms. Most landowners reported regularly pumping their septic tanks and keeping an eye out for proper tank closure and wet spots in the drain field, but for a substantial proportion (one out of four), septic tanks are out of sight and out of mind. Throughout the watershed, there are a few very high-mileage tanks that will require costly updates. Outreach and communication efforts should focus on communicating the importance of having system function evaluated by a professional technician, awareness of problems caused by tree roots growing into the drain field, and evaluating the presence and function of effluent filters in septic systems. There are also new aerobic bioreactor wastewater treatment technologies, such as the SludgeHammer system, that can be added to structurally sound systems to improve or restore function (Pishgar et al., 2021). Residential homeowners are particularly important targets for outreach regarding septic system maintenance and upgrades.

Large farmers were more likely to report that they are protecting streambanks with vegetation and maintaining a six-foot buffer along waterways than were small farmers and residential homeowners with waterways on their properties. Both small and large farms were more likely than homeowners to report improving habitat for wildlife, possibly speaking to greater capacity for implementation on larger land parcels. Outreach regarding riparian zone management should concentrate on homeowners and small farmers who may have fewer professional opportunities to learn about the importance of these management techniques.

Small farmers were more likely to report experiencing time, cost, and equipment barriers to using water quality BMPs in gardens on their properties. They are also in need of assistance with building more sophisticated manure management structures, as only large farms in the watershed reported investing in dry-stacking facilities, or lagoons and biodigesters. Small farms were more likely to report that lacking equipment for manure management limited their use of BMPs and were less likely than large farms to have the information they need to make effective management decisions. Future education and cost-sharing efforts should concentrate on communicating BMP options and implications to small farm operations and providing equipment rentals to address capacity limitations on small farms.

Likewise, large farms are implementing a broader range of water quality BMPs in cropping systems than are small farms, with soil testing and reduced tillage being particularly popular techniques in the watershed. Future outreach should concentrate on small farms that are not connected to federal agricultural conservation programs, but whose aggregated impact on local waterways is substantial.

In sum, a consistent pattern noted in our data was that, as farms scale-up, their professionalization increases the time and resources available for making investments in water quality BMPs. In contrast, small farms may not sustain full-time farm employment or may operate on narrower profit margins (MacDonald et al., 2018), limiting the time and resources available for investing in BMPs. Given the nature of nonresponse bias (Dillman et al., 2014), our survey data may represent farm operations in the watershed with an above-average interest in conservation. Regardless, the fact that the pattern held consistently across all BMPs surveyed suggests that small farms will be particularly important targets for outreach and cost share programs in the future.

Even as we note the potential for greater conservation investments among large farmers compared to small farmers, it's important to remember that many residents expressed concern about the growth of commercial-scale agricultural operations in the watershed. Acute pollution events associated with manure slurry spills have caused particularly alarming fish kills, and survey respondents noted that they believe local fish populations have not recovered from a 2019 manure spill. Going forward, it will be important for operators in the watershed to develop a communication strategy regarding conservation concerns to which they are attuned. Partnering with trusted local Conservation Clubs and county Conservation Districts on demonstration projects, research sites, or sponsoring public events may help increase opportunities for conversation between operators and residents. Building community is key to building trust, as is communicating openly about management actions, and acting with integrity. In the end, the responsibility for stewarding Crockery Creek is shared by everyone in the watershed, and it is in everyone's interest to move beyond blame and work towards solutions.

While many residents wrote warmly about their memories of Crockery Creek, they also expressed frustration at what they perceived to be a state of neglect characterizing present-day management of the creek. For example, one resident wrote:

> "Crockery Creek at the end of Rollenhagen Road has a collection of debris where the bridge washed out decades ago. It is sad what has happened to the creek banks down there. Looks like a forgotten creek... No one has cared for the banks of the creek in so long. It is neglected, it should be protected."

Likewise, a second respondent commented:

> "Crockery Creek has been neglected for many years now. It has progressively gotten much worse. So much has been put into the Grand River and all the money spent on acquiring land along the river that Crockery has gone by the wayside. Explain to me what has taken place on Crockery in the last 50 years? I've not read any publications on what and if anything has been done for Crockery Creek!"

We agree that this state of neglect is unacceptable and have therefore engaged the National Future Farmers of America Organization (FFA) Rural Technology class at Ravenna High School (RHS) to launch a stream monitoring program for Crockery Creek.

Figure 17. Habitat assessment training
Image: Ravenna FFA Facebook

Figure 18. Field trip to GVSU Honors College
Image: Ravenna FFA Facebook

Beginning during the Fall 2022 semester, the GVSU Social Science Lab, the RHS Rural Technology class, and the Ottawa Conservation District pilot tested the project and worked out logistics. RHS students selected six sampling sites along Crockery Creek and collected weekly water samples for five weeks in November. Students collected macroinvertebrates from the stream bed and ran general water quality and nutrient analysis tests in their classroom using Hanna Instruments Backpack Labs. *E. coli* samples were also collected and tests were conducted by GVSU faculty in the Honors College science lab. A website with open educational resources was constructed to assist RHS students with interpreting their monitoring results and relating their data to landowner beliefs and property management practices captured in the Crockery Creek Speaks survey data reviewed in this report.

The spring stream sampling was conducted in April 2023. RHS students demonstrated great determination, braving dynamic weather conditions and high water levels to collect their samples. While macroinvertebrate monitoring was difficult on days when spring precipitation increased stream flow volumes, students observed a greater variety of organisms during the spring sampling period than the fall. The presence of several varieties of pollution-intolerant organisms at several sampling locations reassured us that the creek has potential for supporting aquatic organisms. By collecting observations over time, we hope to be able to more accurately assess aquatic habitat conditions and their consequences.

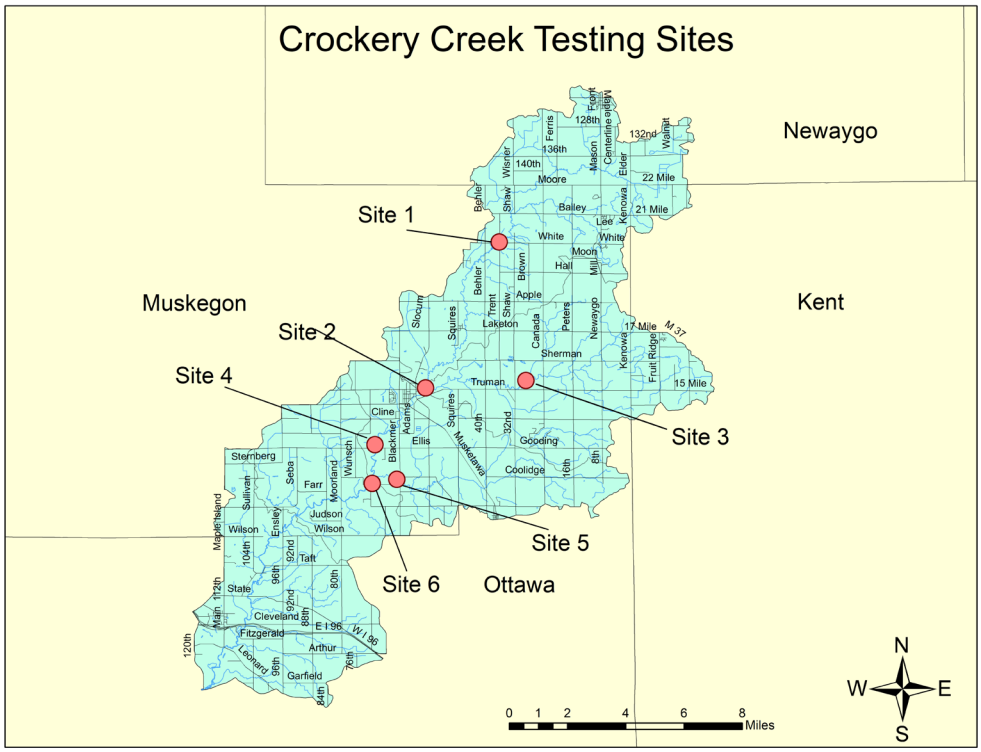

Figure 19. RHS stream monitoring sites, Fall 2022

Much as the weather conditions were more variable during our spring stream sampling, so too were our *E. coli* monitoring results. Whereas the results for the fall sampling were consistently in a moderately-low range, the spring sampling results showed dramatic lows following a short dry spell and dramatic highs following a snow shower. While further observations are certainly needed, a sharp spike in *E. coli* levels following a precipitation event is consistent with runoff-related sources rather than groundwater-fed sources.

Having consistent monitoring data over a long period of time will help us get a clearer picture on what is impacting the creek, as well as where and when interventions are most needed. We have a long way to go and are grateful for the encouragement we've received to get-going on fixing the problems in Crockery Creek.

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Image: Ravenna FFA Facebook